Linac Laser Notcher Status

David Johnson and Todd Johnson

PIP Meeting

October 10, 2012

Beams doc 4237

Reminder: The purpose of the Linac Laser Notcher:

Reduce losses in Booster tunnel generated by the creation of the Notch

→Create notch at 750 keV

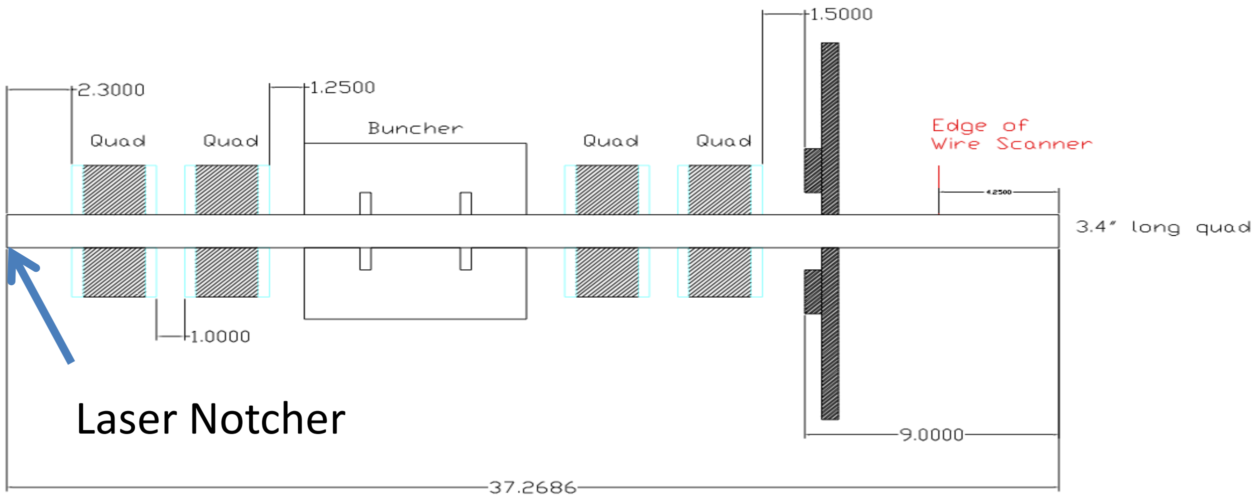
Utilize photo-neutralization (laser system to match temporal structure of H-

Prototype for fast bunch by bunch chopping system

Basic Components

- Pulse Generator/timing system
- Laser system ⇐ update
- Beam shaping ⇐ update
- Optical cavity ⇐ update
- Vacuum interface ⇐ update
- Control system (LabView?)

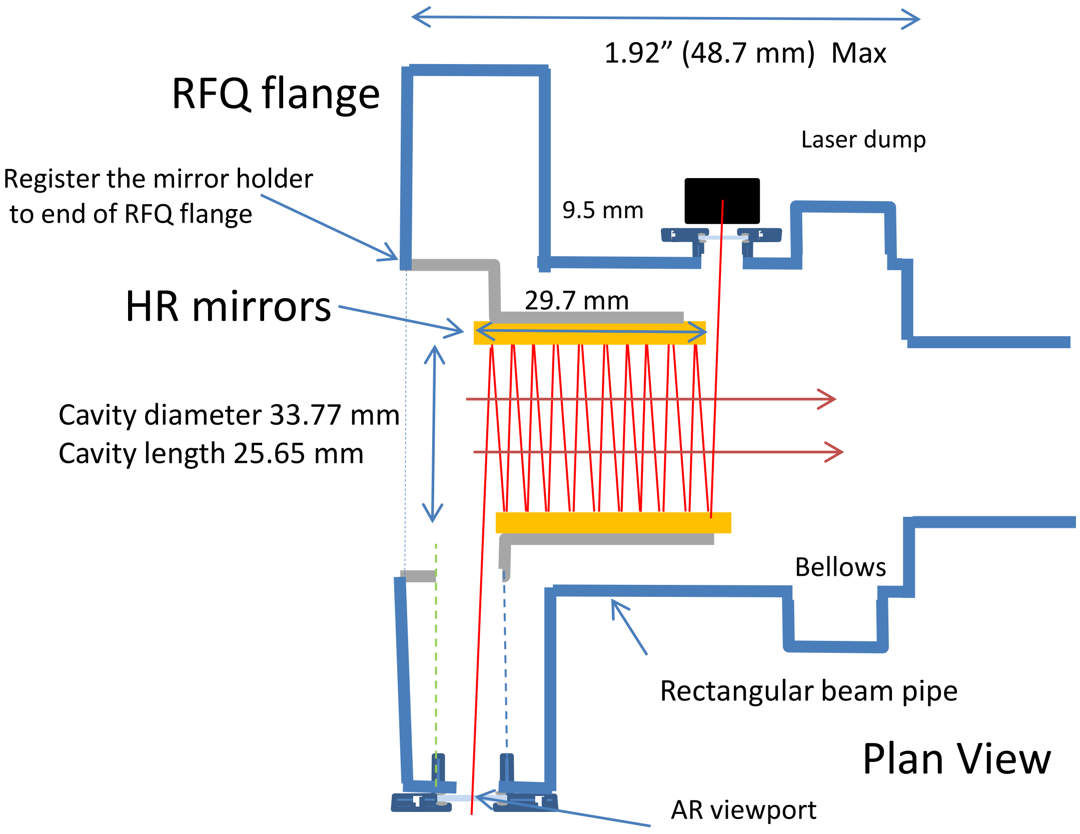
Location Status

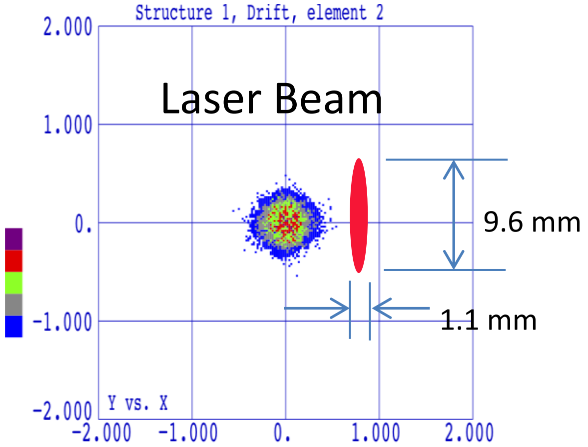
- Initial concept utilized 400 MeV area.
  - Required significant beam line changes
  - Required new H0 absorber (beam dump)
- Back in April decided to focus on 750 keV
- 

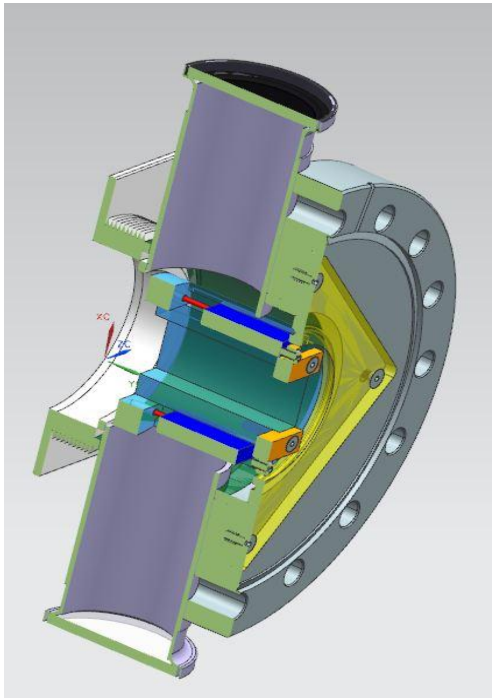
750 keV Notcher Insert Concept

(In flange option)

To reduce laser power: create laser pulse to match spatial and temporal structure of H- beam
And increase interaction time for photo-neutralization through use of zig-zag cavity.



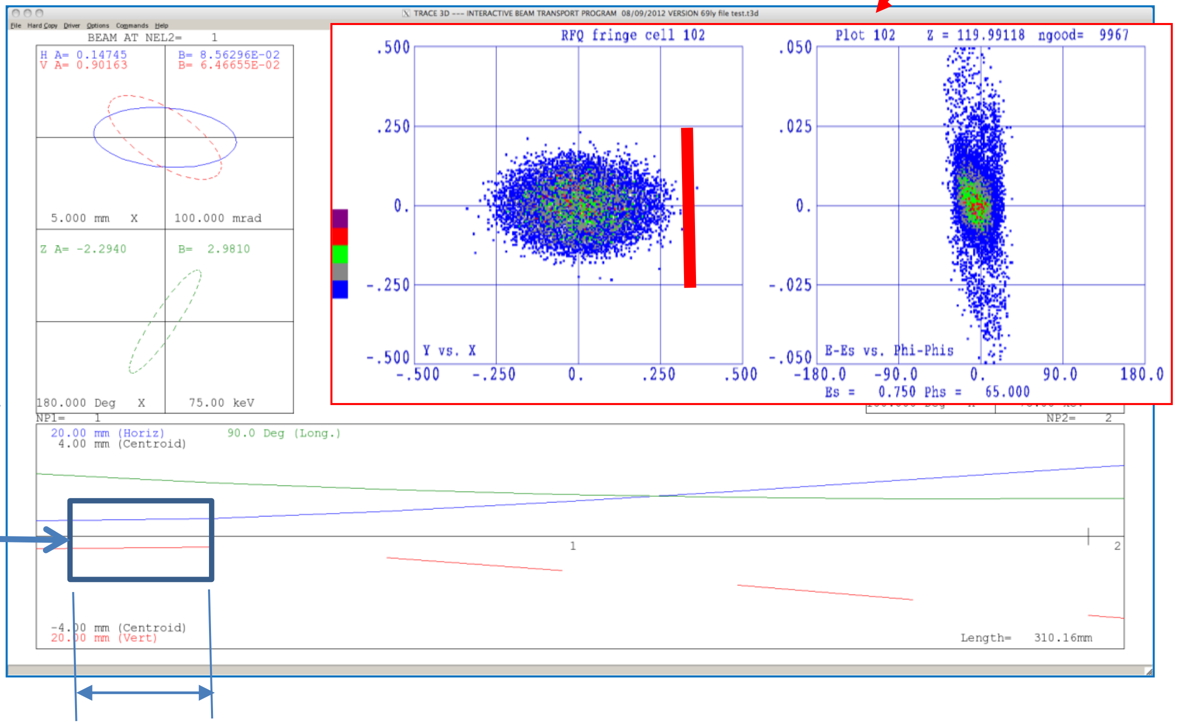




- MS co-op (John Sobolewski) started looking at potential designs of the vacuum system interface. To be continued at a low level effort by MS (co-op)/University collaboration, or other resource.

Expected Beam Dimensions

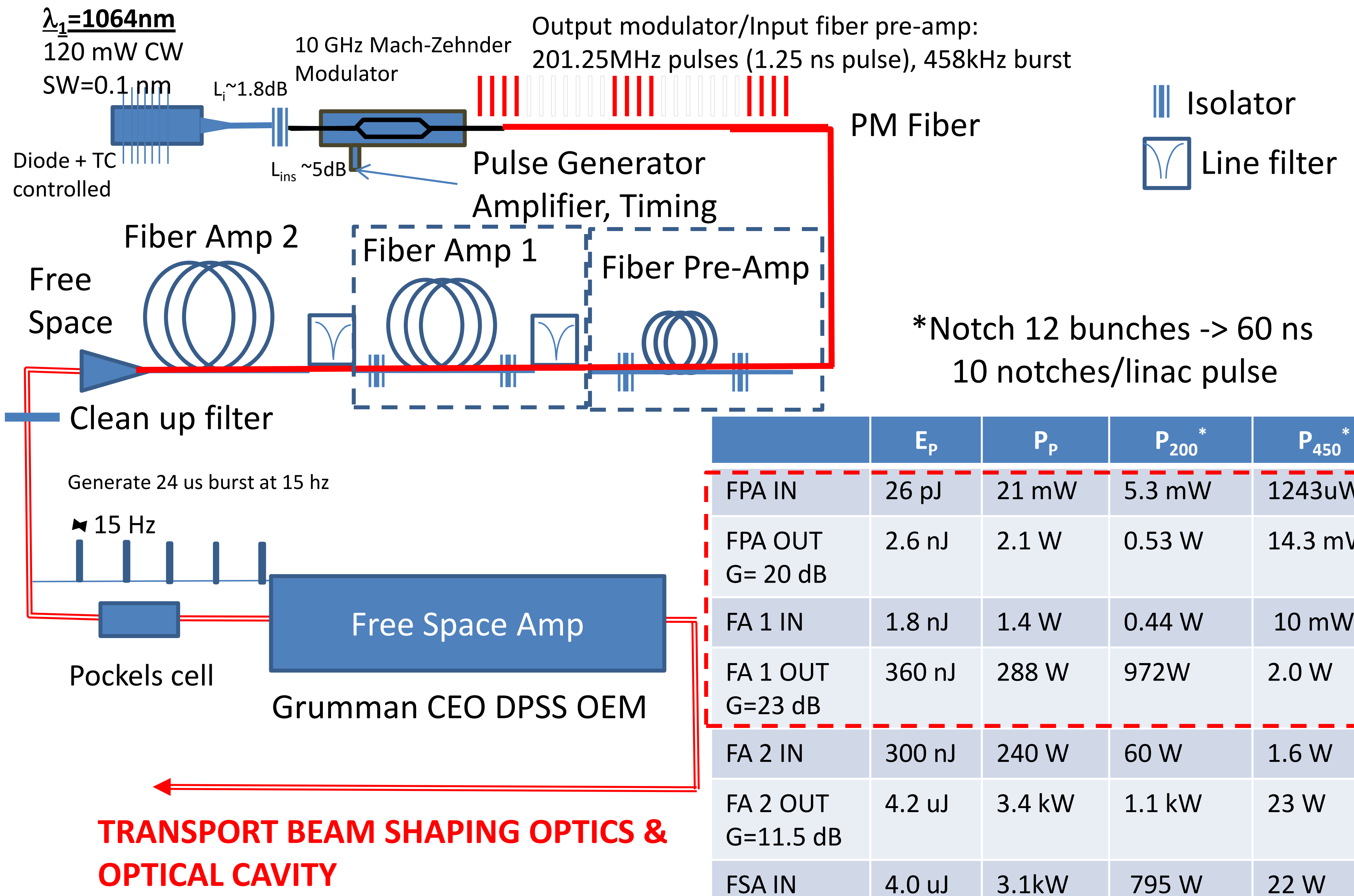
- Trace 3D back calculation of beam size at exit of RFQ based upon emittance measurement at 178 kW power <u>August 9, 2012 CY Tan</u>.
- Phase space simulation at end of RFQ (figure 4.40 of 750 KeV Upgrade Plan)



Laser beam vertical profile ($1/e^2$) ~ 5 mm.

Initial design assumed that the vertical laser beam dimension of 1 cm.
Beam measurements indicate vertical laser size could be reduced to 6 mm
This is a variable parameter in the beam shaping optics.

Burst mode seed pulses to Fiber Amplifier followed by Free Space Amp



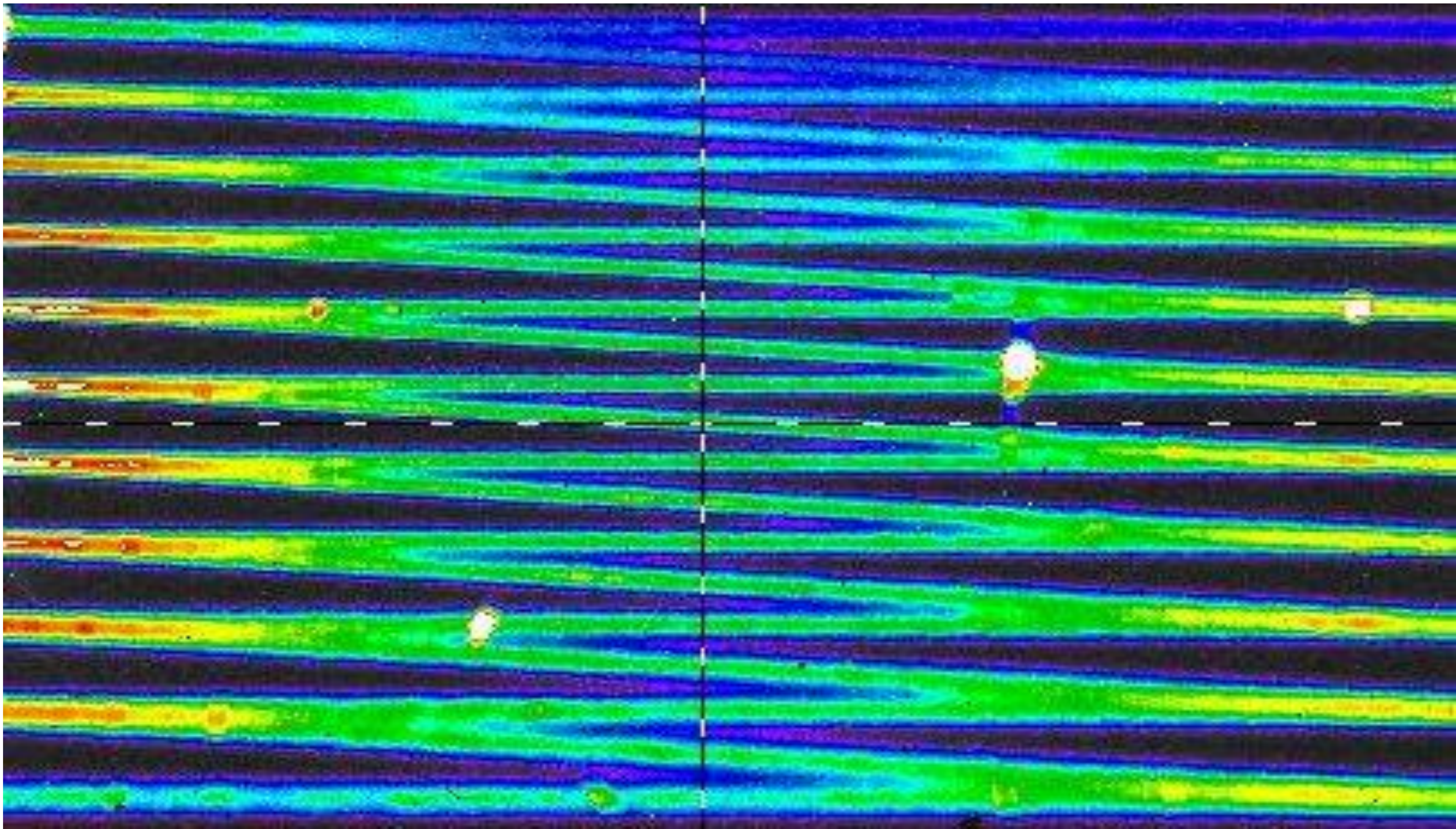
	E_P	P_P	P_{200}*	P_{450}*
FPA IN	26 pJ	21 mW	5.3 mW	1243uW
FPA OUT G= 20 dB	2.6 nJ	2.1 W	0.53 W	14.3 mW
FA 1 IN	1.8 nJ	1.4 W	0.44 W	10 mW
FA 1 OUT G=23 dB	360 nJ	288 W	972W	2.0 W
FA 2 IN	300 nJ	240 W	60 W	1.6 W
FA 2 OUT G=11.5 dB	4.2 uJ	3.4 kW	1.1 kW	23 W
FSA IN	4.0 uJ	3.1kW	795 W	22 W
FSA OUT G=27-29dB	2.0 mJ 3.1 mJ	1.6 MW 2.5 MW	400 kW 630 kW	11 kW 17 kW

Updated 10/3/2012

The Plan (as of today)

- Due to lack of major M&S funding for FY13, we accelerated purchases (with available FY12 funding) planed for FY13 and moved the schedule forward.
- To date we have purchased:
  - Seed laser and controller
  - Modulator system (borrow pulse generator)
  - First 2 stages of fiber amplifier system ***
  - Fiber to free space port
  - Beam shaping optics (532 nm and 1064 nm)
  - Optical cavity components (532 nm and 1064 nm)
- What would we like to accomplish this year (FY13) ?
  - Certify operation and parameterize the following:
    - Optical Pulse Generator
    - 1st two (of three) stages of the fiber amplifier system
    - Beam shaping and transport optics with 532 nm laser
    - Beam shaping and transport optics with the output of the (1st 2 stages) fiber amplifier system (IR)
    - Prototype optical cavity (532 nm in fluorescent cell)
    - Optical cavity with IR
  - Demonstrate 15 Hz burst of the 201.25 MHz and 458 kHz QCW laser pulses with Pockels cell.

Beam shaping and optical cavity tests



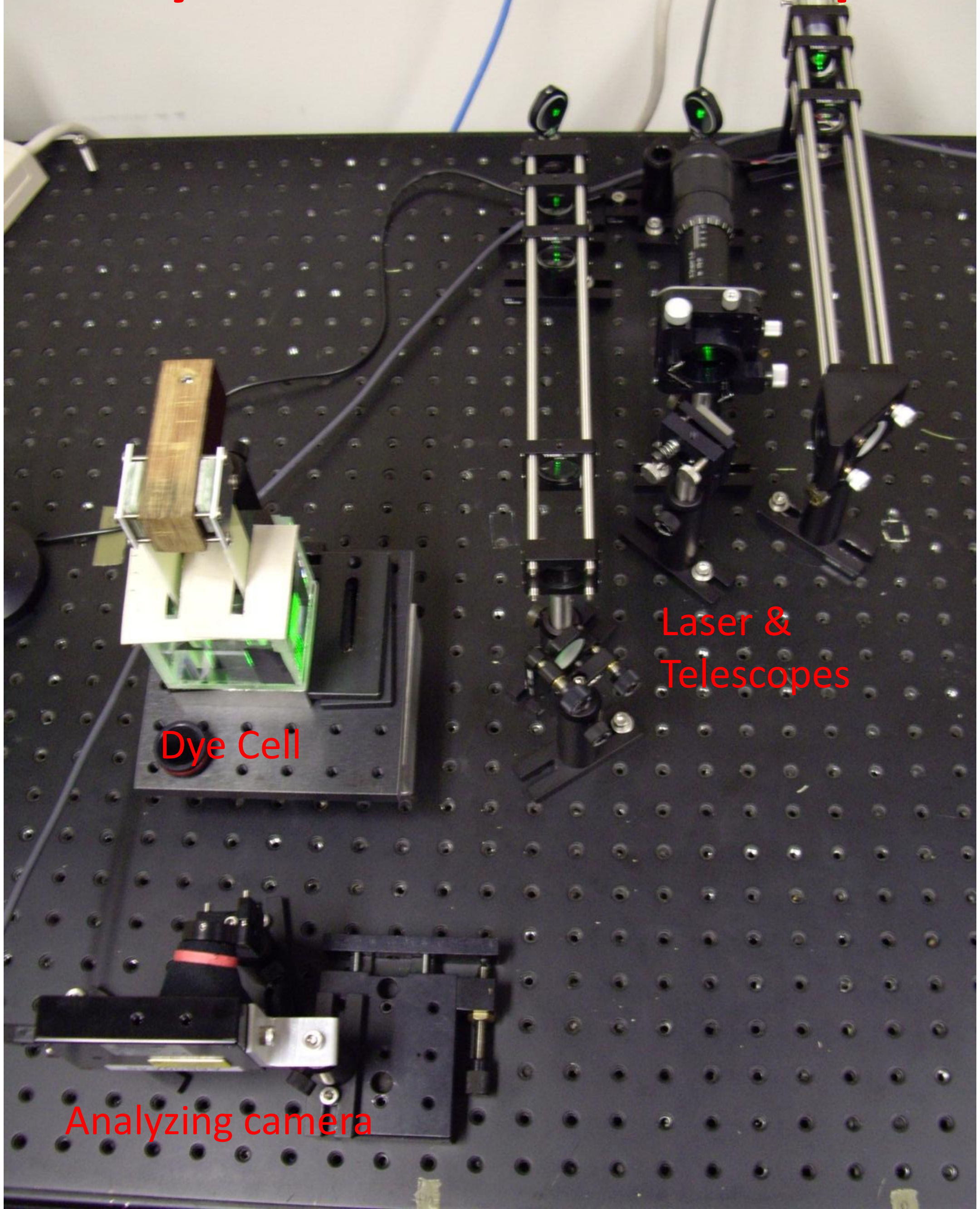
Test setup

In order to evaluate the uniformity of the laser beam profile in the transverse cavity, a dye cell was employed. Water in a clear container is weakly doped with a fluorescent dye which absorbs 532nm from the test laser and re-emits at longer wavelengths, allowing any scattered portions of the primary beam to be filtered out and rejected from the analysis.

Two initial approaches:

- Fill aperture with a “staircase” of overlapping elliptical gaussian beams to present a uniform optical field to the ion beam.
- Utilize a “PiShaper”; an optical device which converts a gaussian profile beam to one with a flat-top profile, to produce a vertically uniform beam which fills the aperture.

Dye cell test setup

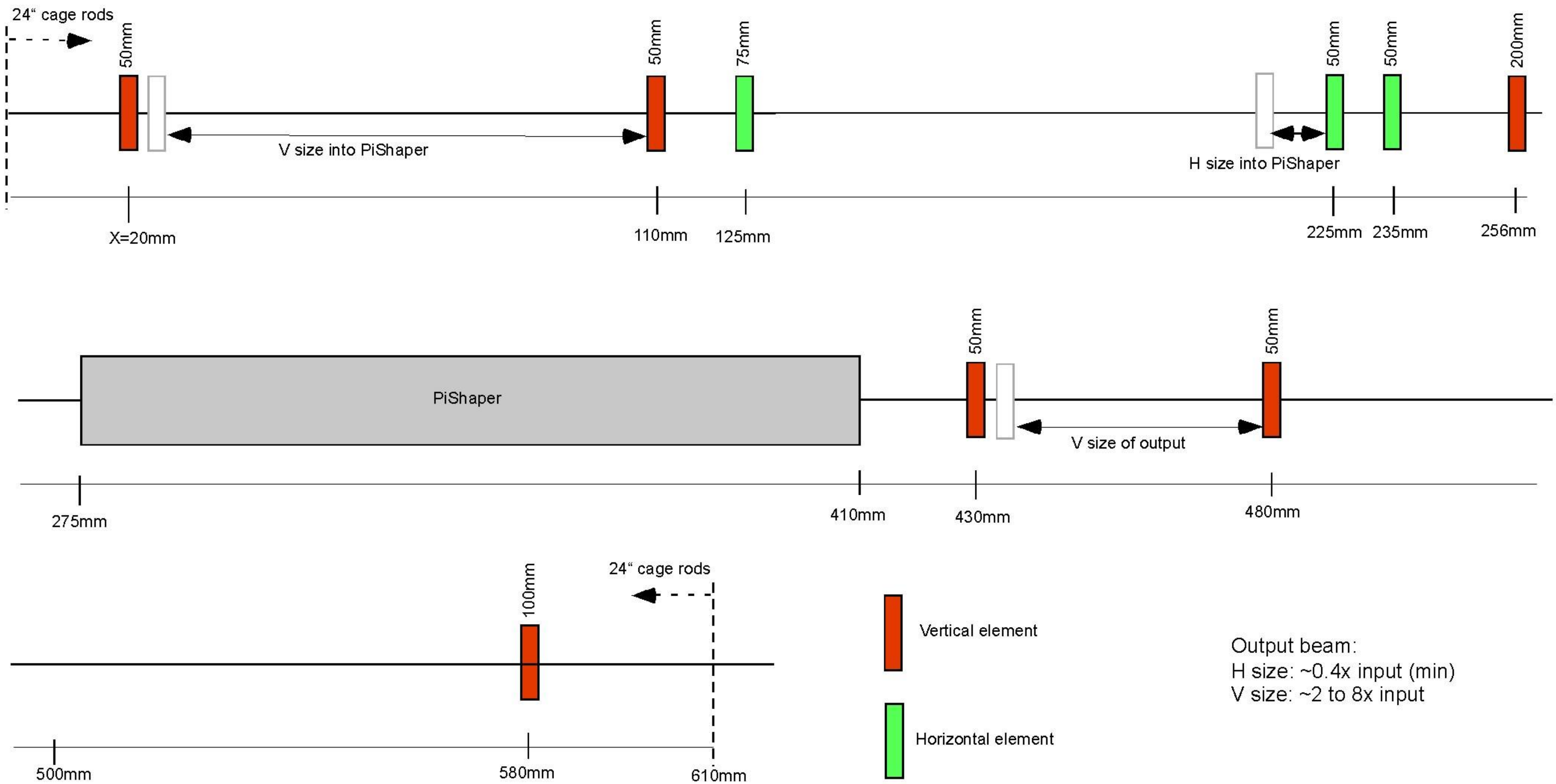


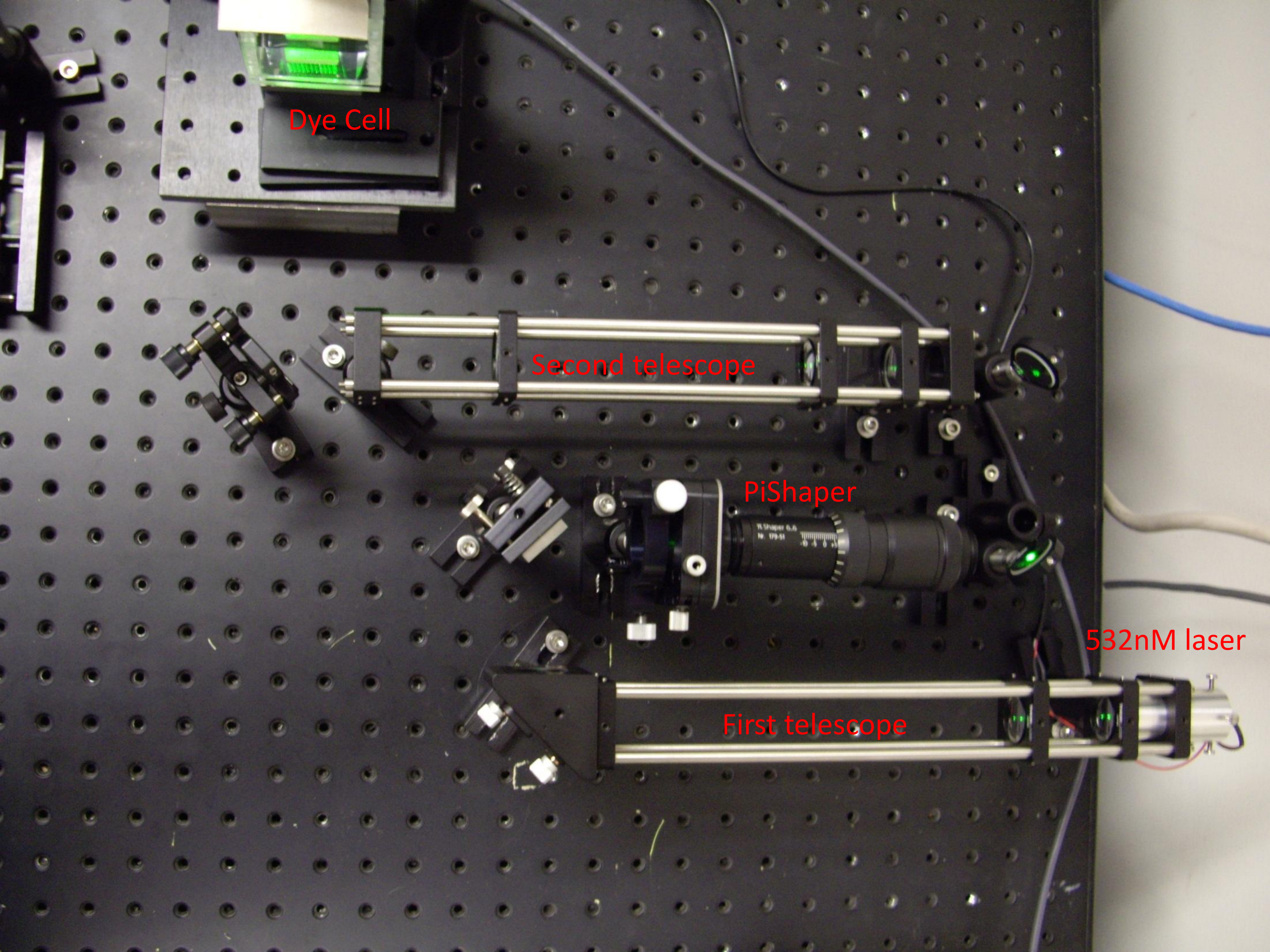
Telescopes

- The test optics consist of two variable magnification cylindrical telescopes and the PiShaper device.
- The PiShaper function depends critically on proper input beam characteristics, so the first telescope is used to deliver an appropriately sized elliptical beam to the PiShaper. The second telescope is used to expand the 6mm output of the PiShaper to any desired vertical size up to 25mm.

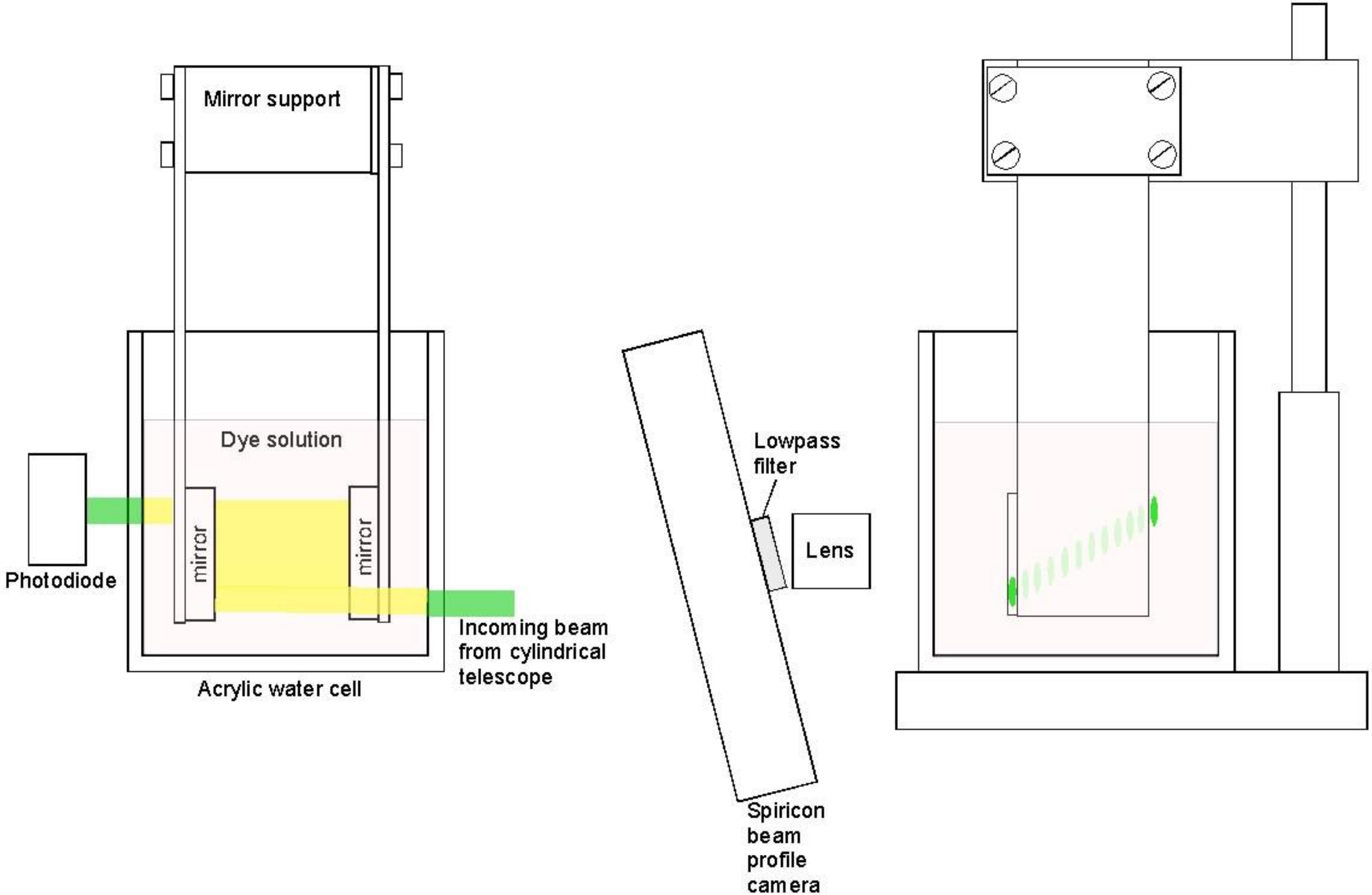
750 Laser Notcher Anamorphic Telescope

T. Johnson 8/13/2012

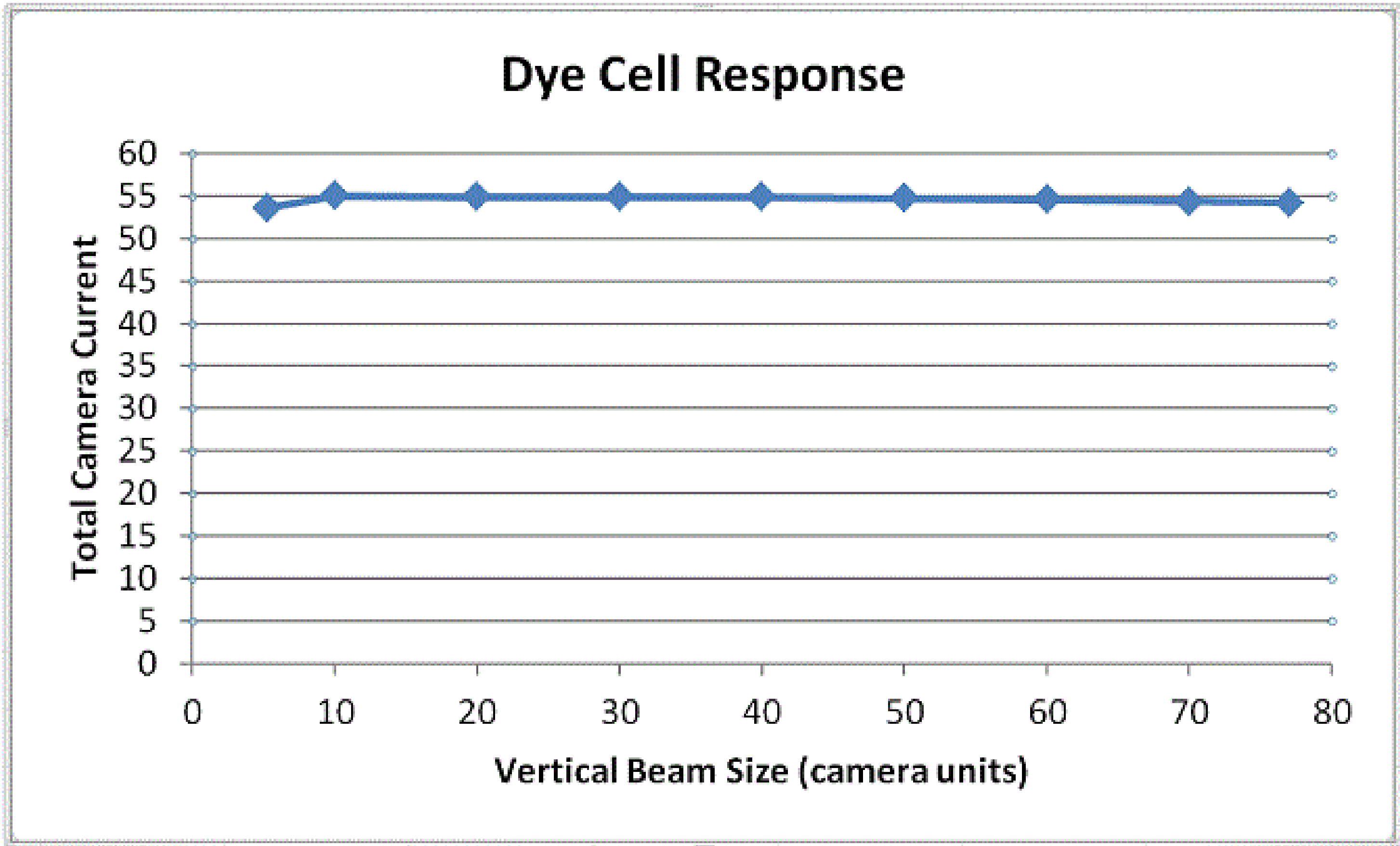


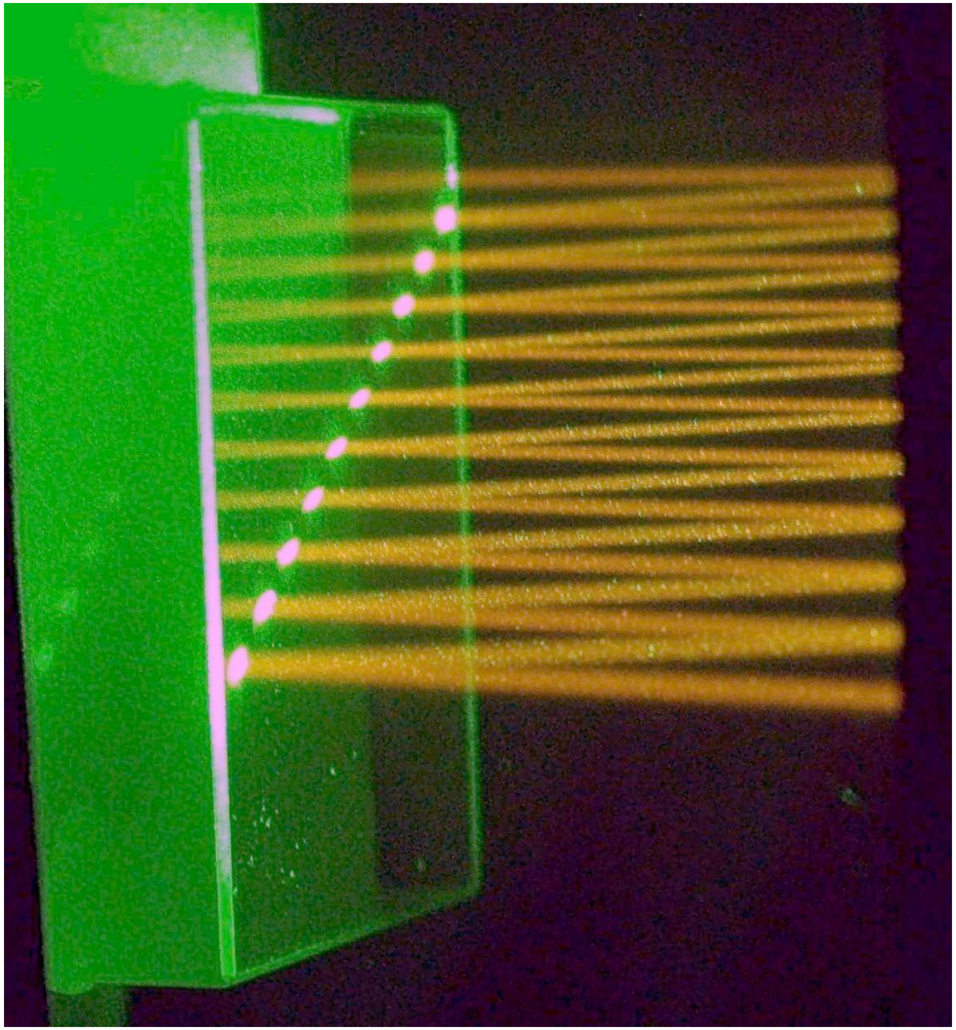

Dye Cell
Second telescope
PiShaper
532nM laser
First telescope

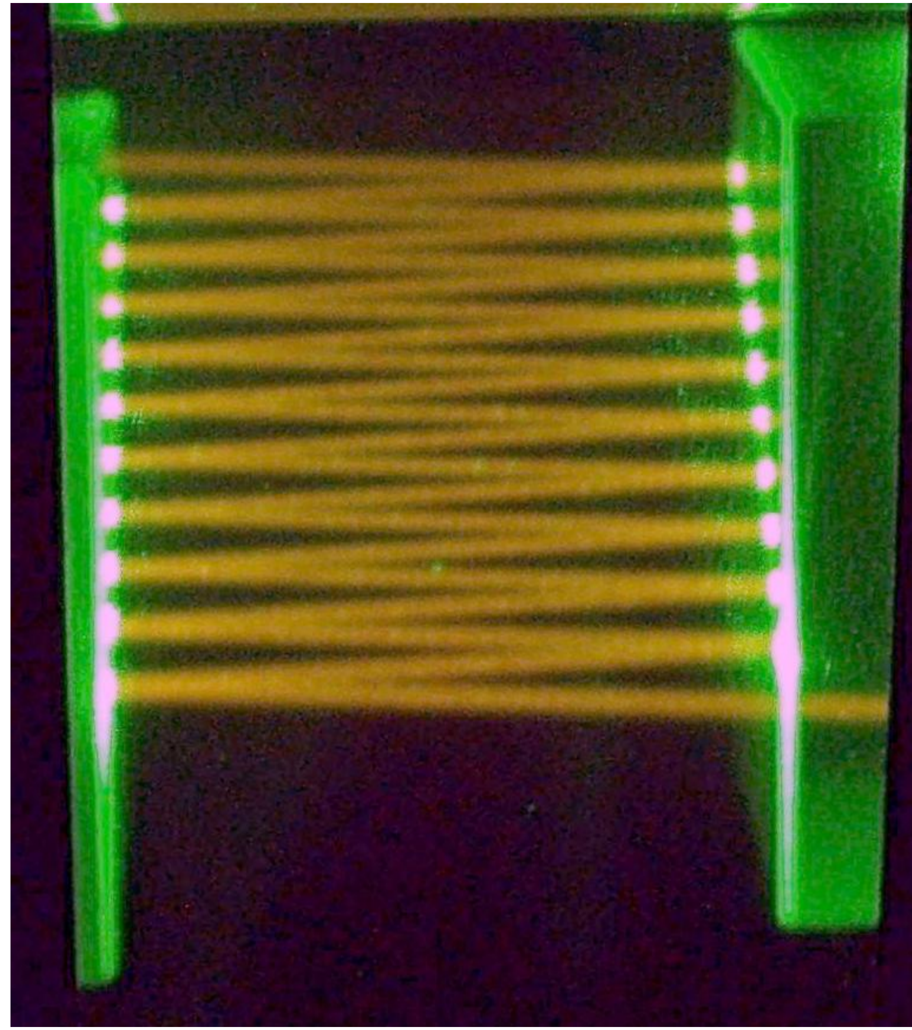
Dye cell for analysis of transverse "zig-zag" cavity



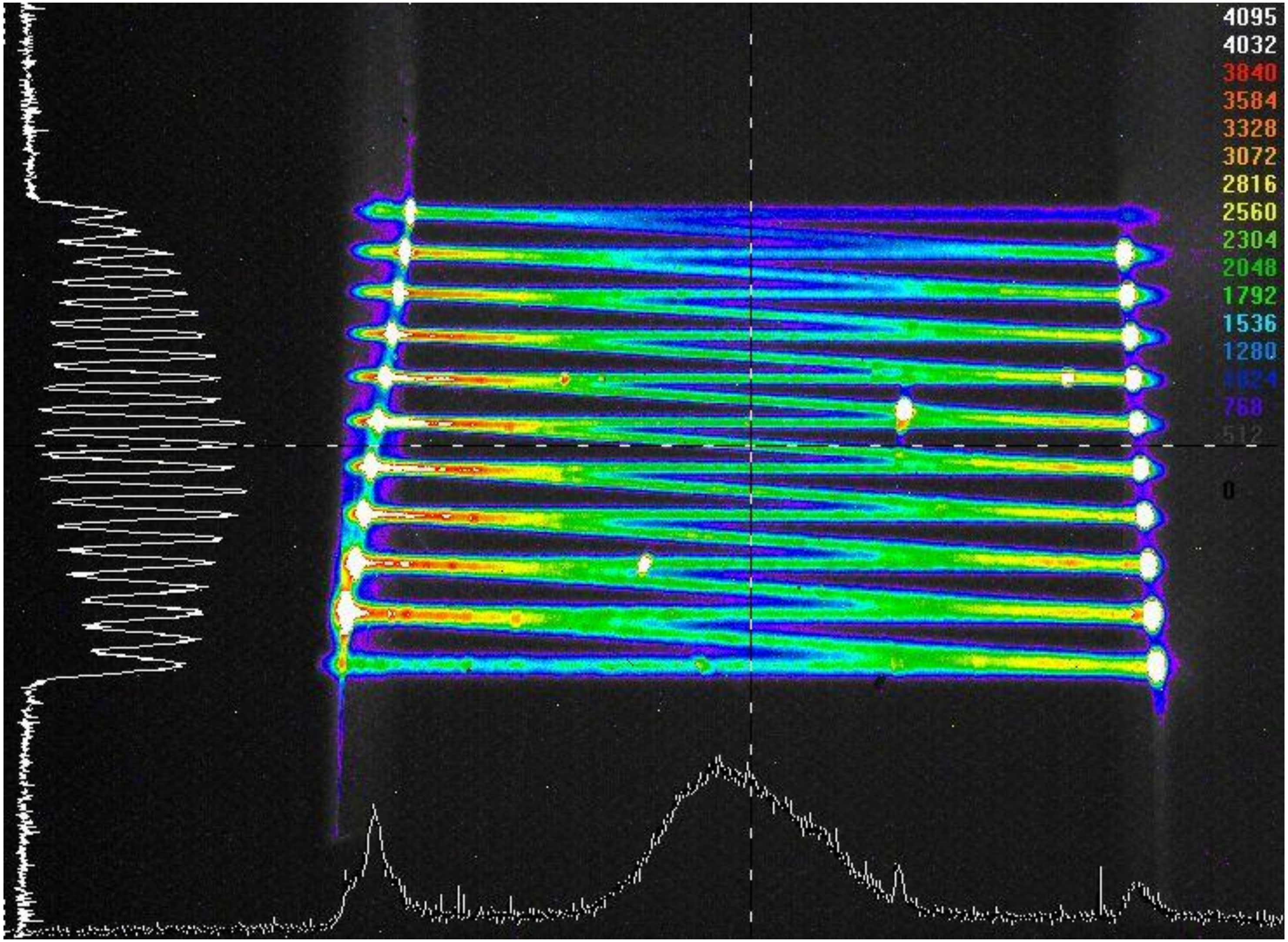
Response of the dye was tested to ensure linear behavior with varying primary beam intensity



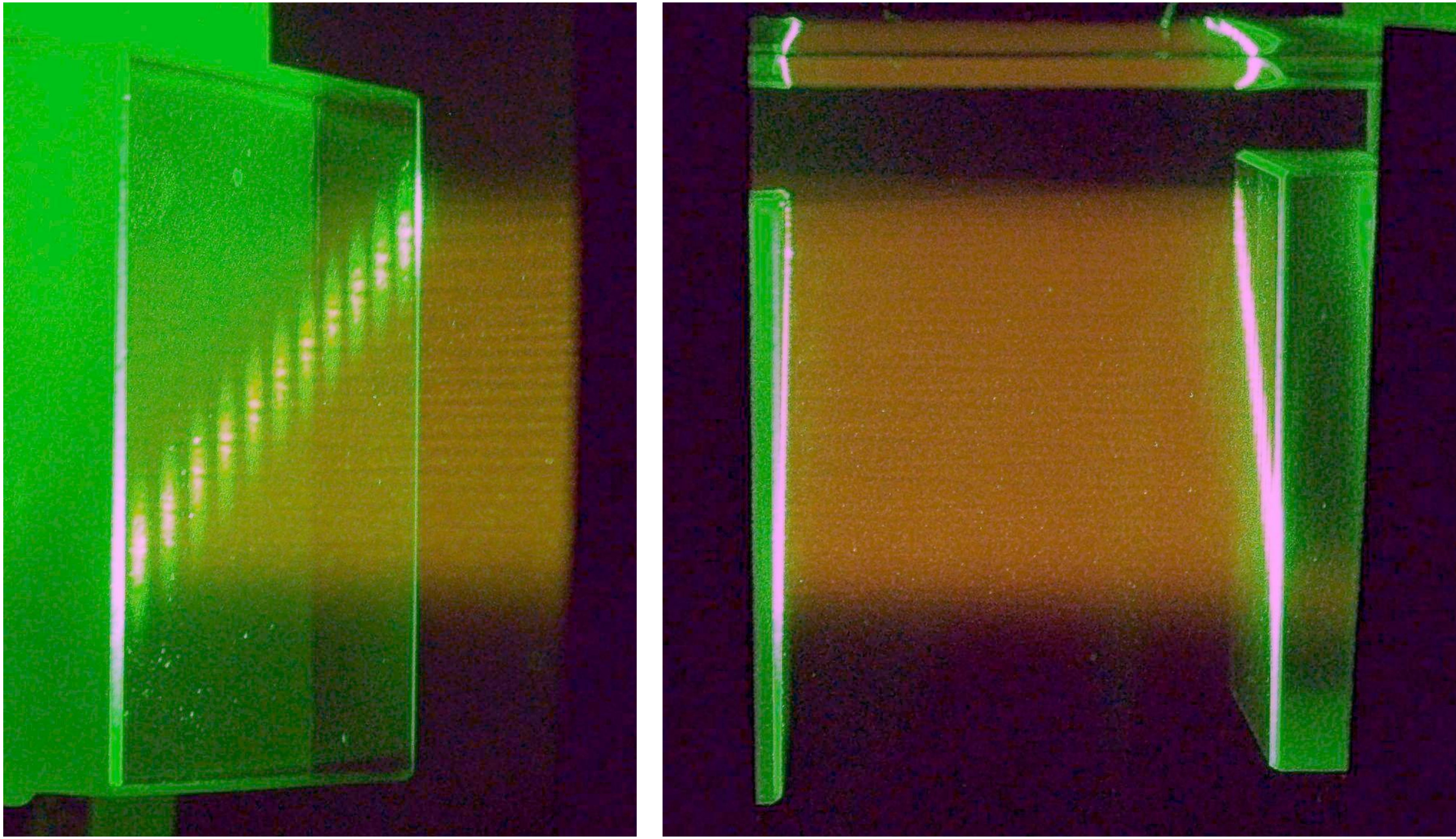




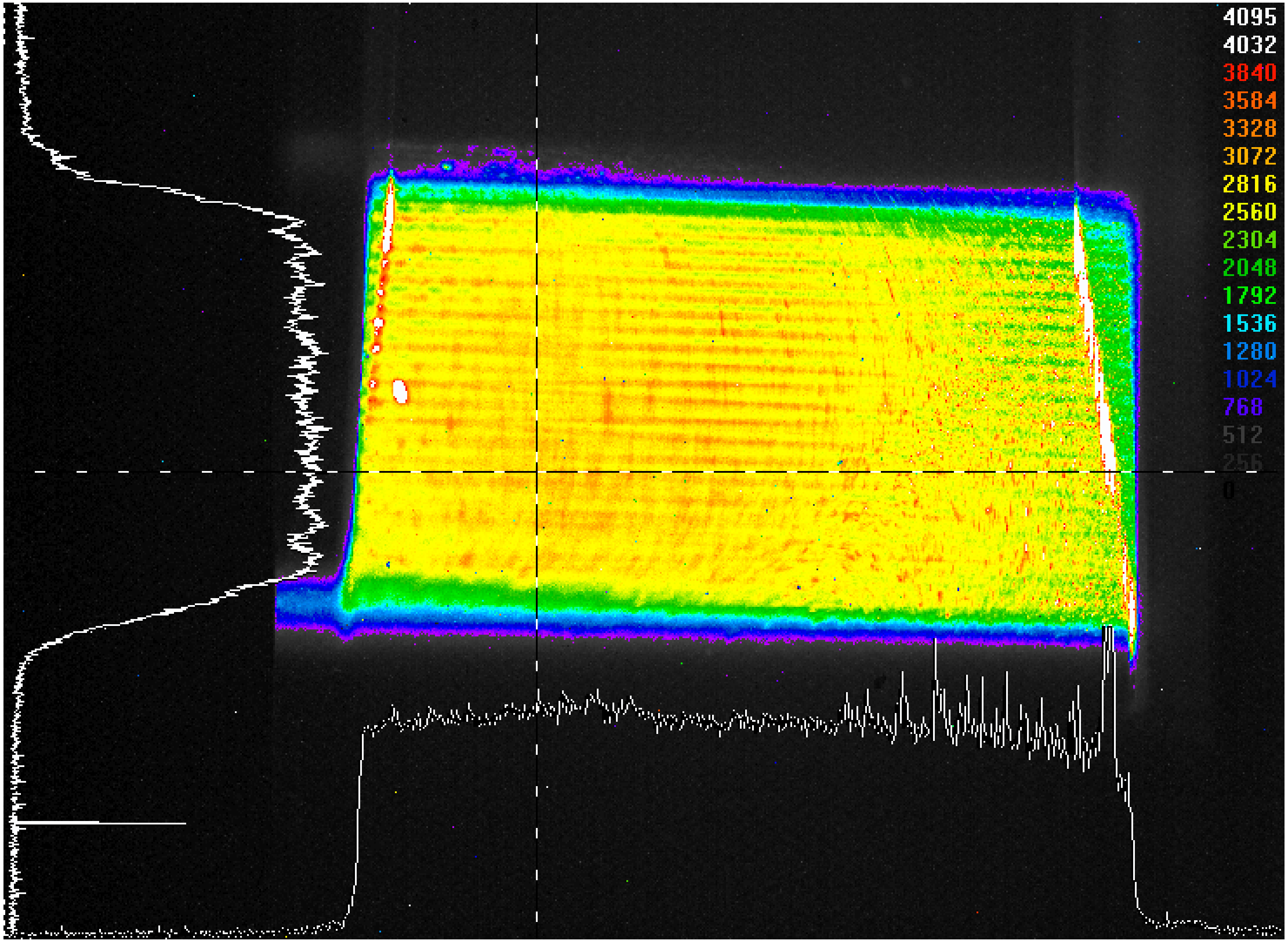
Aligning cavity mirrors in the dye cell with unexpanded beam



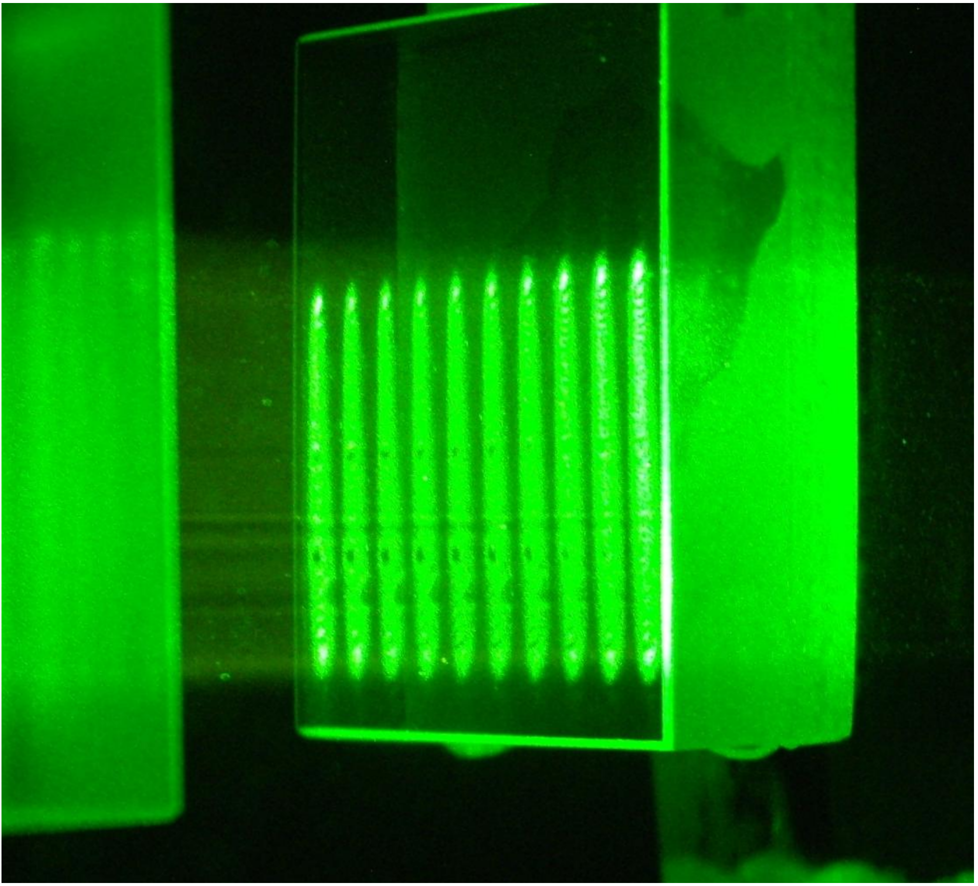
Profile of unexpanded staircase trajectory
(Spiricon camera with 600nM lowpass filter)

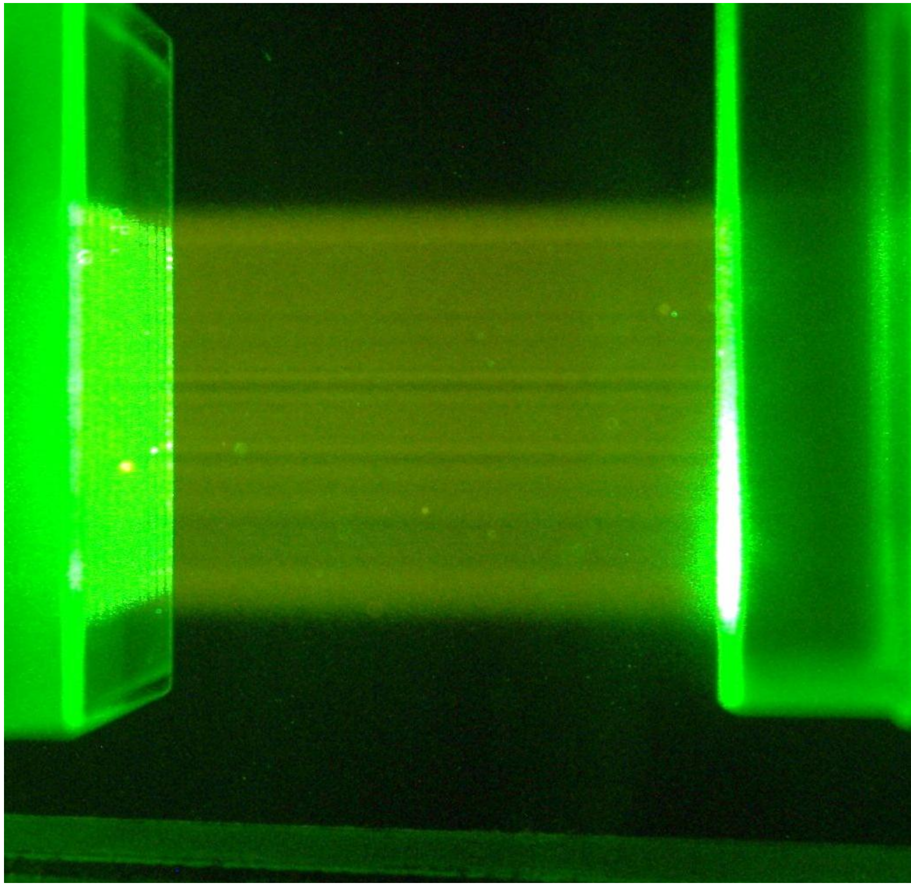


Beam expanded vertically with first telescope (no PiShaper)
and propagated in the overlapping staircase configuration

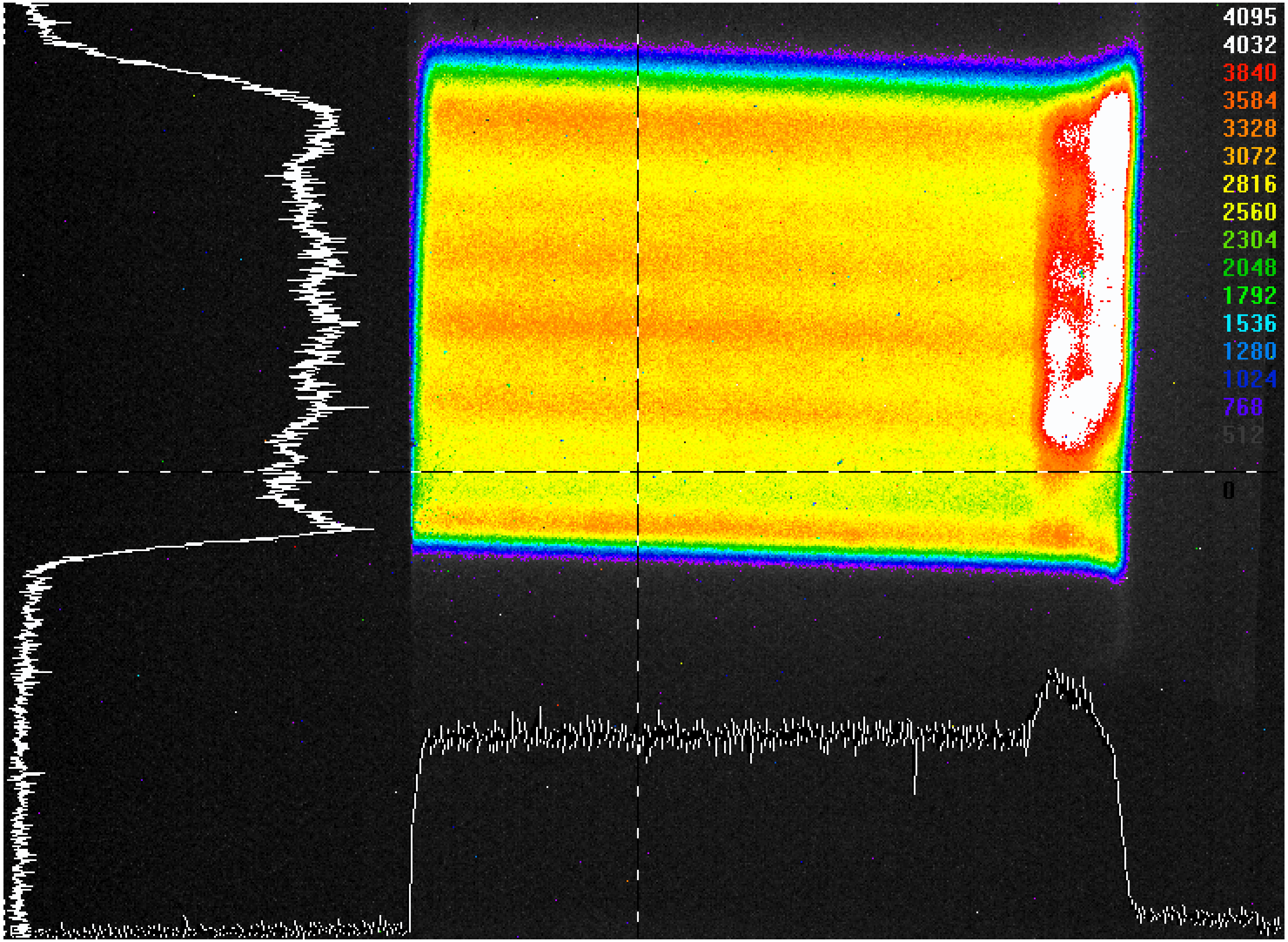


Resulting profile of staircase configuration
(Spiricon camera w 600nM lowpass filter)

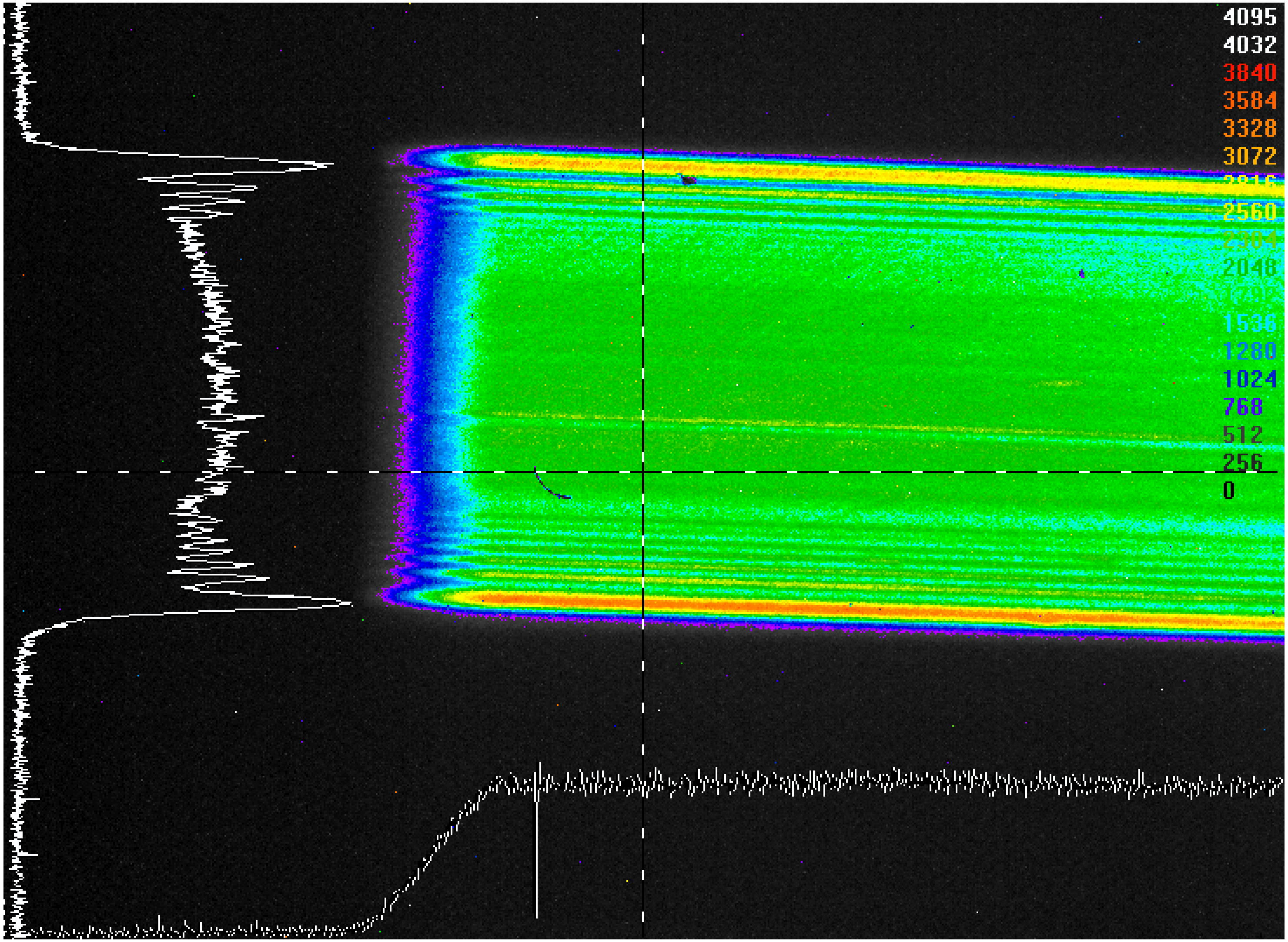




Beam expanded through both telescopes and processed with PiShaper



Profile of overlapping PiShaper output
(Spiricon camera with 600 nM lowpass filter)



Single pass expanded PiShaper beam

(Fine adjustment of the input beam parameters will reportedly remove much of the observed structure.)

Conclusions

Variable beam shaping telescopes performed as expected.

The PiShaper is very sensitive to input conditions. Additional tuning is needed to take full advantage of this device.

Both methods of producing a vertically uniform optical field in the zig-zag cavity showed promising results.